Photo by: K.M. Kettenring

Final report to USFWS

Phragmites invasion and control in the Great Salt Lake watershed: 2012 land manager survey

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Cite as: Kettenring, K.M., K. Garvie, E.L.G. Hazelton, N. Hough-Snee, and Z. Ma. 2014. *Phragmites* invasion and control in the Great Salt Lake watershed: 2012 land manager survey. Final report to the USFWS. 26 pp.

Executive summary

We surveyed land managers in the Great Salt Lake (GSL) watershed to look at the timing of *Phragmites* invasion, factors potentially contributing to its invasion, current *Phragmites* management practices, and how *Phragmites* management may conflict with other land management activities. Key findings of our survey from 42 respondents are:

Timing, initial causes, and current extent of invasion

- Receding water lines within the GSL watershed was cited as the main event that allowed for the establishment of *Phragmites*. In addition, 88% of respondents felt that their management activities initially contributed to the spread of *Phragmites* on their property.
- GSL other managers (all managers except duck clubs) had the most total acres of *Phragmites* on their land (51,652 acres), followed by Utah Lake (15,130), GSL duck clubs (2,380), and Bear Lake (1,225). The average percent of managed land (includes all uplands, wetlands, and open water) containing *Phragmites* was much lower for Bear Lake (1%) than the GSL (11%) or Utah Lake (5%).

Current Phragmites *management practices*

- A lower percentage of land managers surveyed currently manage *Phragmites* at Bear Lake than the other areas (67% vs. 92% for GSL duck clubs, 94% for the GSL other managers, and 86% for Utah Lake).
- GSL duck clubs were the first to control *Phragmites*, and on average began control efforts nearly 10 years before the rest of the land managers on the GSL.
- The top four treatments that managers use to control *Phragmites* are: herbicide (97% of respondents), burning (65%), livestock grazing (49%), and mowing (43%). All 24 respondents who burn also use herbicide. More land managers apply herbicide in the fall (28) than summer (20). The most common sequence of treatments is fall spray followed by a late winter/early spring burn (28% of respondents).
- Respondents stressed the importance of *Phragmites* biomass removal (either by burning, mowing, or grazing) to increase the effectiveness of herbicide.
- Numerous respondents suggested that grazing is a cost-effective method of *Phragmites* management in areas that can be dried out enough to allow for it.
- A total of 11 respondents seeded or planted target species after invasive *Phragmites* control. For land managers who do not seed, 86% "did not think it was necessary."

Challenges affecting current management practices

- *Phragmites* management often conflicts with other management objectives; in particular the personnel / time and costs associated with herbicide application were cited as the biggest challenges to balancing *Phragmites* control with other land management.

- Weather and air quality permitting were the greatest limitations to using burning for *Phragmites* control. Water levels and *Phragmites* density most often restricted grazing as a control method while water levels, weather, and personnel availability most often restricted mowing activities.

It is our hope that these research findings, along with our on-going *Phragmites* treatment experiments, will aid in the development of a comprehensive *Phragmites* management strategy for our region.

Background

This survey targeted wetland managers across public and private lands in the Great Salt Lake (GSL) watershed who have invasive *Phragmites* on their land, and are either currently working to control *Phragmites* as a part of their management strategy, or plan to do so in the future. The objectives of our survey were to:

1. Gain insight into the potential causes and timing of initial *Phragmites* invasion in the GSL watershed.
2. Assess how land managers have dealt with *Phragmites*, what their broad goals and specific objectives are for *Phragmites* control, and outline their most successful methods of control.
3. Determine the trade-offs between different *Phragmites* control treatments and what factors may limit control success.
4. Determine what potential conflicts might occur between *Phragmites* control efforts and other management objectives / activities.
5. Aid in the development of a comprehensive *Phragmites* management strategy for our region, including decision-making frameworks and monitoring protocols for land managers.

Survey methodology

Considering the goals of the survey, we tried to obtain responses from as many land managers as possible who had invasive *Phragmites* on their land. We targeted government, private duck club, and private non-profit land managers, and excluded private homeowners from our survey. All land managers for whom we were able to obtain contact information were contacted via phone, email, or both over a four month period (February - May 2012). In accordance with standard survey protocol, respondents were contacted more than once if necessary to increase response rate (Dillman 2000). The overall survey response rate was 78% (42 out of 54 land managers contacted).

Throughout the summary, questions answered by all respondents have a sample size of N=42. For conditional questions, we denote how the sample size was adjusted based on how many respondents answered the question.

Results

Overview of management areas and presence of Phragmites

The majority of respondents manage land on the shoreline of the three major bodies of water within the GSL watershed – the GSL (29 respondents, one includes the Jordan River, which flows from Utah Lake into the GSL), Utah Lake (7), and Bear Lake (6), for a total of 42 surveys (**Figure 1**). Approximately 1/3 of surveys were from private duck clubs on the GSL

representing a total of 18 individual duck clubs as some managers oversee more than one duck club. There are no duck clubs on Bear Lake or Utah Lake. Overall, more than half of all respondents (22) were from either state or federal agencies (**Figure 2**). Three respondents chose two or three organization types, the rest chose a single organization type.

The survey provided general information about the size and habitat type of managed areas. Most respondents characterized their wetlands as a mix of open water, emergent wetland, riparian area, seasonally flooded flat/playa, moist soil management area, and grassland / shrubland. Sixty percent of respondents (25) attempt to increase cover or density of particular plant species to manage for certain habitats and/or land uses (N=42). Across all major wetland habitat types, the species most widely managed for are: sago pondweed (*Stuckenia* pectinata; 68%), alkali bulrush (*Schoenoplectus/Scirpus maritimus*; 68%), saltgrass (*Distichlis spicata*; 60%), pickleweed (*Salicornia* spp.), native grasses (56%), and willows (*Salix* spp.; 56%) (N=25).

Acres of land under management jurisdiction ranged from 21 acres to ~1.4 million acres, with a median area of ~3,095 acres (N=40; **Figure 3**). Eighteen respondents (45%) had 2,500 acres or less and six respondents (15%) had 500 acres or less (**Figure 4**). Three respondents had acreage well over 100,000 acres – one at 250,000, and two at over a million (1.2 and 1.4 million acres). Twenty one respondents (54%) actively managed 100% of their acreage, with respondents managing a mean of 74% of their land (N=39).

The top current objectives for land managers are waterfowl habitat or production (81%), non-waterfowl *wetland* habitat (62%), non-waterfowl *upland* habitat (60%), livestock grazing (55%) and public wildlife viewing/education (43%) (N=42) (**Table 1**). Eleven respondents also specifically mentioned recreation and/or hunting in the "other" category. The relative ranking of historic objectives was similar to current although the overall percentages for current objectives were higher (more respondents filled out a current objective) (**Table 1**). Not surprisingly, there was a difference between historic and current objectives for nine respondents (21%). The shift involved livestock grazing for five out of those nine. Three respondents (33.3%, N=9) who *did not* historically manage for livestock grazing currently do. Two respondents (22.2%) who *did* historically manage for livestock grazing currently do not. The remaining respondents (3) historically managed for livestock grazing and one or two other objectives and currently expanded their objectives to include two to four additional objectives. Interestingly, three respondents also began managing for public wildlife viewing/education in the last 5 years.

In terms of total acres, GSL other managers had the most total acres of *Phragmites* (51,652 acres), followed by Utah Lake (15,130), GSL duck clubs (2,380), and Bear Lake (1,225) (**Figure 5**). Overall, the mean area of invasive *Phragmites* per land manager was 1,759 acres (median 125 acres). The largest area of *Phragmites* for a single respondent was 30,800 acres (out of 1,374,467). To put the total acres of *Phragmites* into perspective, at ~4,400 km^2 the GSL is more than 10 times the size of Bear Lake or Utah Lake, which explains why the majority of acres of *Phragmites* were reported for this area (even after accounting for the greater number of

GSL respondents). It is interesting to note that while Bear Lake is approximately ¾ the size of Utah Lake (~280 km^2 versus ~380 km^2), Bear Lake managers reported less than $1/10^{th}$ the amount of *Phragmites* of Utah Lake managers. The amount of *Phragmites* in Utah Lake is roughly proportional to its size relative to the GSL.

For the majority of respondents (76%, N=38), *Phragmites* comprised between 1 and 10% of total land area on their property (**Figure 6**). The highest percentage of *Phragmites* was 46% (150 out of 325 acres) and the minimum percentage was 0.03% *Phragmites* (1 out of 3000 acres), for a mean of 8% (median 4%) of total acres (**Figure 5**). Duck clubs reported almost twice as much *Phragmites* (14% of land managed) as the rest of the GSL managers on a percentage basis (8%) (**Figure 7**). This finding might be attributed to the fact that duck club managers can give more accurate estimates on their smaller parcels of land rather than necessarily having a higher percentage of *Phragmites*. At the other extreme, the percent of managed land (uplands, wetlands, and open water) containing *Phragmites* was about 1% for Bear Lake land managers.

It is important to note that not all *Phragmites* is invasive – native *Phragmites* is also present in the GSL watershed (Kulmatiski et al. 2011, Kettenring and Mock 2012). Forty-four percent of respondents (17) stated that they personally knew how to differentiate native vs. invasive (non-native) *Phragmites* (N=39). Sixteen respondents (41%) claim to have native *Phragmites* on their property, nine (23%) do not, and fourteen (36%) are not sure (N=39). Of those with native *Phragmites*, five manage to *decrease* its cover or density while the rest *do not* attempt to change its cover or density (and no one manages specifically to *increase* native *Phragmites*). More than half of respondents (51%) consider native *Phragmites* beneficial habitat for wildlife (N=37). Interestingly, two respondents manage to decrease native *Phragmites* even though they consider it beneficial habitat.

Timing and cause of invasion

For Bear Lake, the timing of *Phragmites* first detection ranged from 1996-2012. For Utah Lake, one respondent said 1980s, another said 1998. For the GSL, more than half of the respondents (16 out of 29) specifically cited the GSL flood of the mid-1980s/early 1990s and four more wrote a date corresponding to the flood (whether they mentioned it directly or not). Similarly, 23 out of 33 respondents said that the arrival of *Phragmites* on their property appeared to coincide with abnormal weather or events. Seven respondents (22%) had aerial imagery or other documentation showing when *Phragmites* was first detected on their property (N=34).

Even though flooding or drought seemed to be a contributing factor in allowing invasive *Phragmites* to establish, 88% of respondents also thought that their management activities (water management, vegetation management, or both) contributed to the introduction or spread of invasive *Phragmites* on their property (N=32) (Figure 8). At the time of detection, most

respondents were managing their land for both waterfowl habitat or production (82%) and non-waterfowl wetland/upland habitat (50%) (choices were not mutually exclusive, N=28).

Historic and current control of Phragmites

GSL duck clubs were the first land manager group to control *Phragmites*, and on average began control efforts nearly 10 years before the rest of the land managers on the GSL (**Figure 9**). The more recent invasion of *Phragmites* at Bear Lake could explain why a smaller percentage of land managers are controlling invasive *Phragmites* at Bear Lake. Alternatively, there may be less control occurring because there is less *Phragmites* or because there was a bias in our survey respondents since we did not target private land owners, who may own significant amounts of land with *Phragmites.*

Eighty-eight percent of respondents (37) currently control *Phragmites*. Of those, the top four treatments are: herbicide (97%), burning (65%), livestock grazing (49%) and mowing (43%) (**Figure 10**). Overall, current methods of *Phragmites* control have remained relatively proportional to historic, the exception being a drop in the use of discing from 6 to 2 respondents (**Figure 10**). Of the 36 who currently use herbicides, 30 provided additional information about type of herbicide and application rates. Twenty-nine of them use glyphosate, seven use imazaypyr, one used Quest (an ammonium fertilizer), and 18 also use surfactant. Six of the seven people using imazapyr also used glyphosate.

The most common times for land managers to apply herbicide are fall (28) or summer (20), while burning tends to be done in the spring (20) or fall (9) (**Figure 11**). Mowing appears to largely occur in the summer and fall. Some control methods such as grazing and flooding are largely carried out year round. The spikes in herbicide application and burning in **Figure 11** coincide with the burn and spray (or spray and burn) sequence of treatments used by a large number of land managers.

A majority of respondents (66%) referred to a specific sequence of treatments to control *Phragmites* within the last 5 years (N=38). The most common sequence of treatments is fall spray followed by a late winter / early spring burn (28%). Three respondents (8%) reported using a spring burn followed with a summer spray. Eight respondents (21%) cited spraying in the summer, followed by burn in fall or trample winter (3), a burn in spring (2), flood winter/spring (1), or summer mow (1). Overall, some combination of burning and spraying was mentioned by 20 respondents (53%). All GSL duck clubs use herbicide except for one, which has yet to begin any *Phragmites* treatment.

There is also a direct correlation between the number of control methods used and the amount of *Phragmites* by management area. Bear Lake managers, dealing with ~1% *Phragmites*, use an average of 1.4 control methods. GSL duck club managers, with the largest percentage of *Phragmites* (14%), average 4.4 control methods. This does not mean that

managers are using four treatments across all acres (different areas are better suited to certain treatments) but it does show that GSL duck clubs have the most diverse and/or intense management schedules. Six of the seven respondents using only one control method used herbicide (other was mowing). All 24 respondents who used burning also used herbicide (i.e. burning was never used alone). One manager reported the use of seven current control methods and three use six methods (combinations unknown). The average across all managers was 3.3 control methods.

Respondents stressed the importance of burning dead *Phragmites* to remove the previous year's biomass to increase the effectiveness of subsequent herbicide treatments. Grazing and mowing also reduce biomass to allow for more effective spraying. In addition to being the most cost effective, respondents noted that grazing has the advantage of removing seeds before pollination, reducing spread through rhizomes, speeding decomposition, and allowing other species to come in. Mowing and flooding can also stunt growth to prevent seed development.

In terms of broad goals for *Phragmites* control in the last 5 years, 61% of respondents (23) would like to stop the expansion of *Phragmites*, 45% (17) would like to eradicate it, and 37% (14) would like to reduce it to a certain size or percentage. For specific objectives, 58% have a goal in terms of acres or percentage of *Phragmites*/land. Eight respondents would like to treat 100% of their *Phragmites*, and four of these respondents are from duck clubs. Those treating 100% of their *Phragmites* have between 1 and 700 acres of *Phragmites* (mean=149 acres). On average, respondents would like to treat about 78% of their existing *Phragmites* on a yearly basis.

Twenty-one respondents provided estimates for herbicide costs and there was no obvious relationship between acres of *Phragmites* and costs. Estimates for materials ranged from $2 per acre to $855 per acre. Labor estimates were similarly wide ranging – from $12 per acre to $2,000 per acre. Estimates for duck clubs and state/federal agencies are relatively comparable ($7 to $75 per acre for materials and $12-$75 per acre for labor).

Management conflicts

The survey addressed two types of conflicts – when efforts to control invasive *Phragmites* conflicted with other management objectives (**Figure 12**) and the various factors that can affect four major *Phragmites* control methods (mowing, livestock grazing, burning, and flooding) (**Table 2**). For *Phragmites* control conflicting with other management objectives, respondents cited budget conflict for herbicide more than any other control method (12 respondents versus 4 for grazing and mowing), reflecting the budget strain of expensive aerial application or necessary personnel time required for ground application. Grazing on the other hand either has little to no cost or generates income (according to 10 respondents) so does not negatively influence budget (**Figure 12**). Equipment and personnel/time are the factors that affect grazing most frequently.

For factors affecting individual *Phragmites* control methods, weather and air quality/permitting were cited as major factors affecting burning for 20 respondents (**Table 2**). Although GSL duck clubs have a greater ability to acquire a burn permit than federal or state agencies (personal communication), there was no difference in survey results concerning permits between these two groups. One respondent said bird nesting affected their ability to burn. Burning can also negatively affect hunting as one respondent pointed out: the sharp burnt stems that remain damage the paws of hunting dogs. The main factors limiting livestock grazing were water levels (8) and density of *Phragmites* (7). Water levels also affected mowing (10) as well as weather (10) and personnel availability (9). This supports our personal communications with land managers over concern about having the right type of mower for deep water conditions and the time it takes to mow *Phragmites* (it can take an entire day just to clear 2 acres). Timing of water rights (5) and the ability to flood (4) most negatively affect the use of flooding to control *Phragmites* (**Table 2**).

Restoration efforts

Eleven respondents (30%) have seeded or planted after *Phragmites* control (N=37). Among these respondents, six harvested on site, six purchased from a nursery, and one obtained seeds from the Utah Division of Wildlife Resources (choices were not mutually exclusive). The different types of managers that seeded were GSL duck clubs (33% of respondents), 5 GSL other managers, and 2 Utah Lake managers. No one reseeded at Bear Lake. The top reason for not reseeding across the watershed was because the respondent "did not think it was necessary" (86% of respondents, N=22), followed by too costly to pay personnel (27%), and too costly to acquire seeds/plants (32%). Another 32% of respondents chose "other" and cited more specific reasons, such as "fluctuating lake level", "money and time", "wanted unvegetated mudflats", "seed source available on site already", or "proved ineffective with huge native dormant seed bank available".

Following *Phragmites* control, 100% (N=39) of managers prefer either a particular native species or *any* native species to take its place and aim to avoid the establishment of non-native plants and any other invasive plant. Greater than 50% of respondents selected alkali bulrush, hardstem bulrush, common threesquare, and/or salt grass as their preferred species to replace *Phragmites* (**Table 3**). The most common plants that managers aim to avoid coming back after *Phragmites* control are non-native thistles, poison hemlock, any invasive or non-native plant, non-native cattail, and hybrid cattail (**Figure 13**).

Acknowledgements

We are grateful to the many land managers who graciously donated their time to fill out our lengthy survey.

Literature cited

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Kulmatiski, A., K. H. Beard, L. A. Meyerson, J. R. Gibson, and K. E. Mock. 2011. Nonnative *Phragmites australis* invasion into Utah wetlands. Western North American Naturalist 70:541-552.

Figures and Tables.

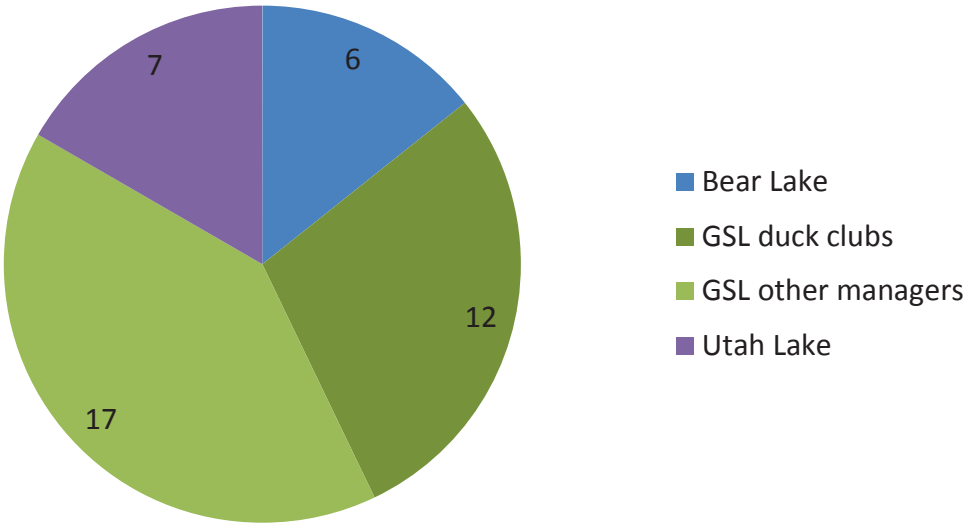

Figure 1. Survey respondents categorized by management area, N=42.

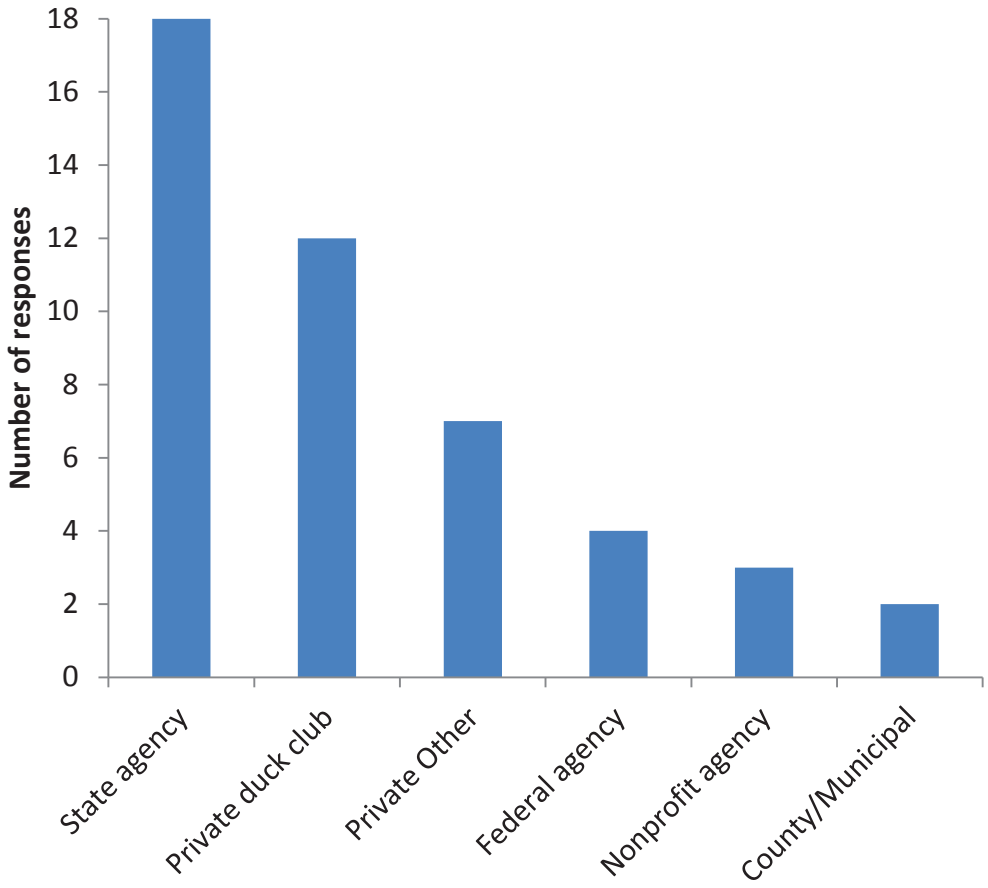

Figure 2. Type of organization that respondents belong to (choices not mutually exclusive, N=42).

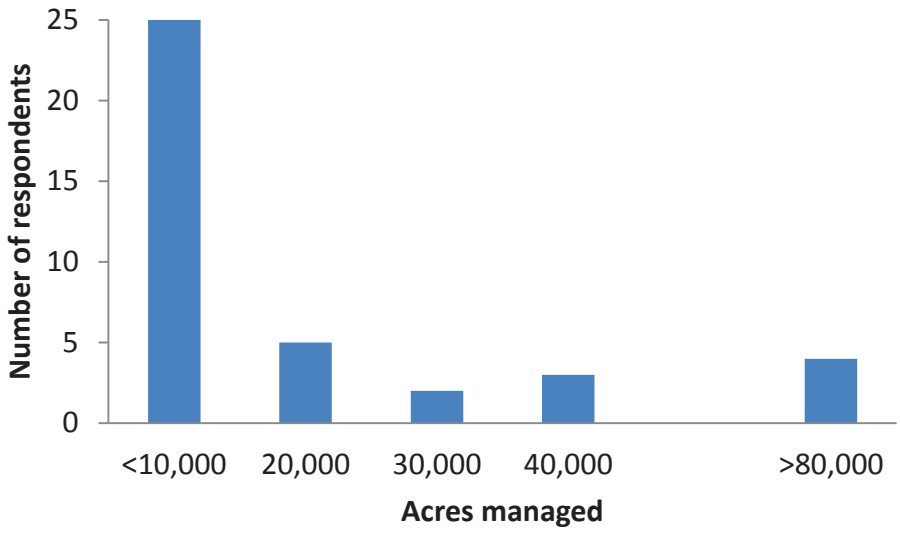

Figure 3. Frequency distribution of all respondents for acres managed in increments of 10,000 acres (N=40).

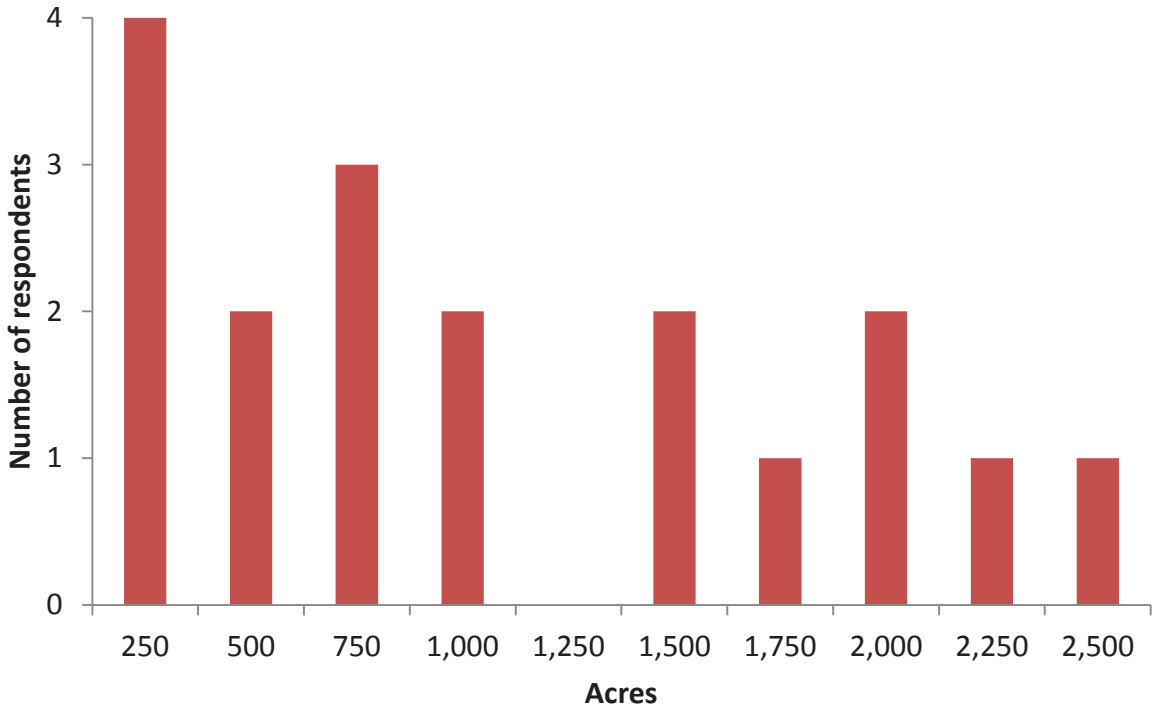

Figure 4. Frequency distribution for respondents with 2,500 acres or less (N=18).

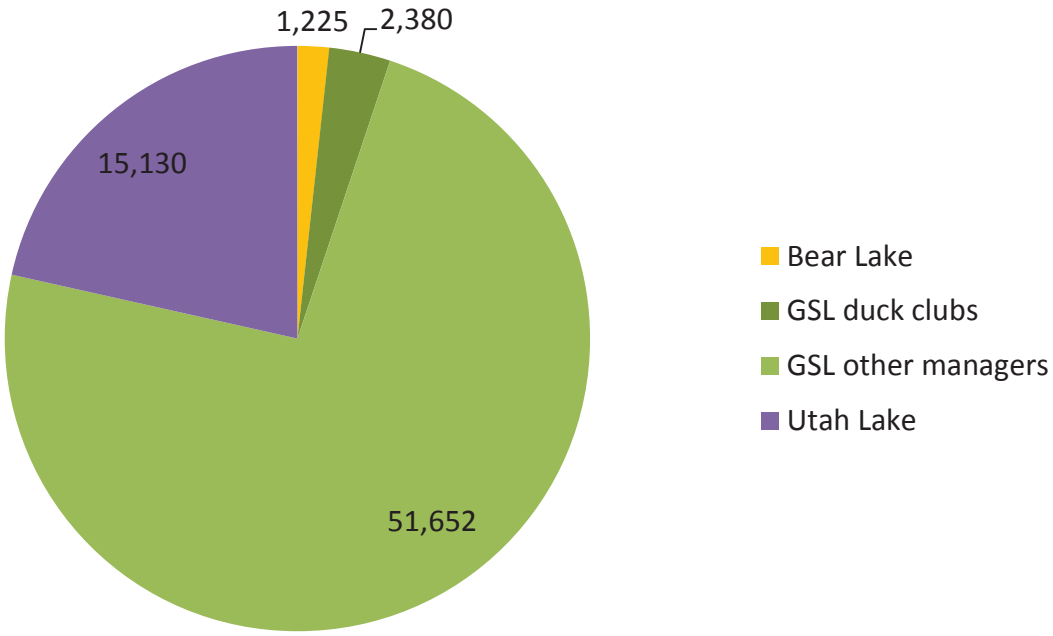

Figure 5. Total acres of *Phragmites* reported by respondents (N=40); we only surveyed managers who have *Phragmites* on their property. Total for all managers = 70,387 acres.

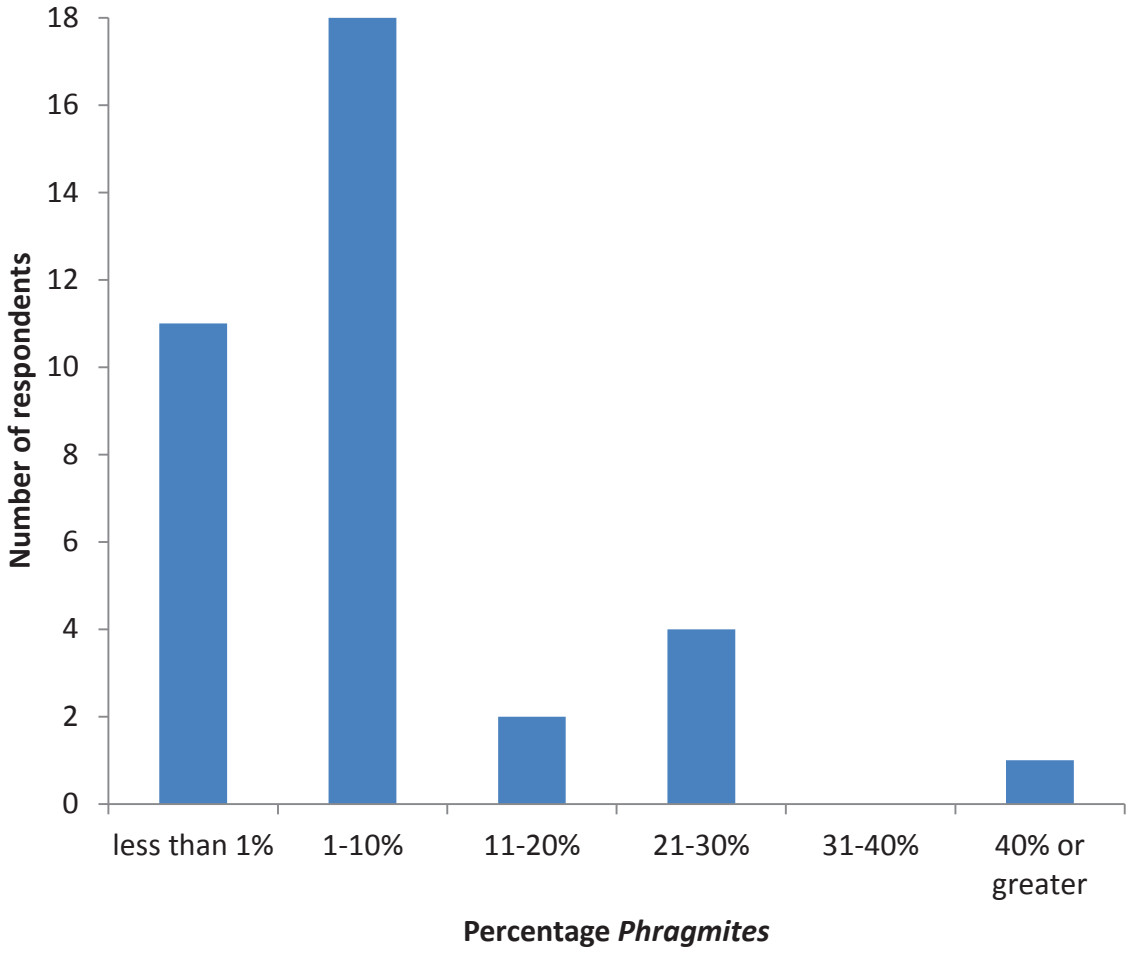

Figure 6. Average percentage of managed land containing invasive *Phragmites* per land manager (out of total acres managed, which includes upland and open water areas). (N=38)

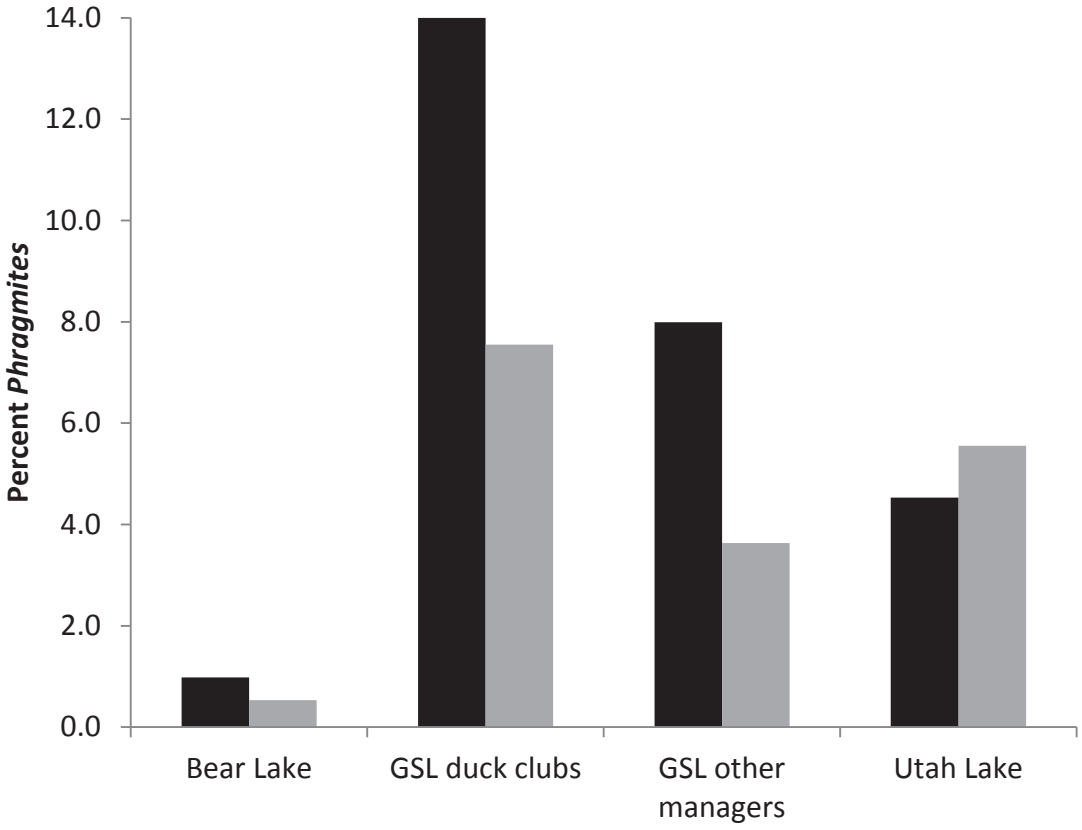

Figure 7. Reported percent *Phragmites* by management area. Black bars represent mean, gray bars represent median percent *Phragmites*. Bear Lake N=6, GSL duck clubs N=12, GSL other managers N=17, and Utah Lake N=7.

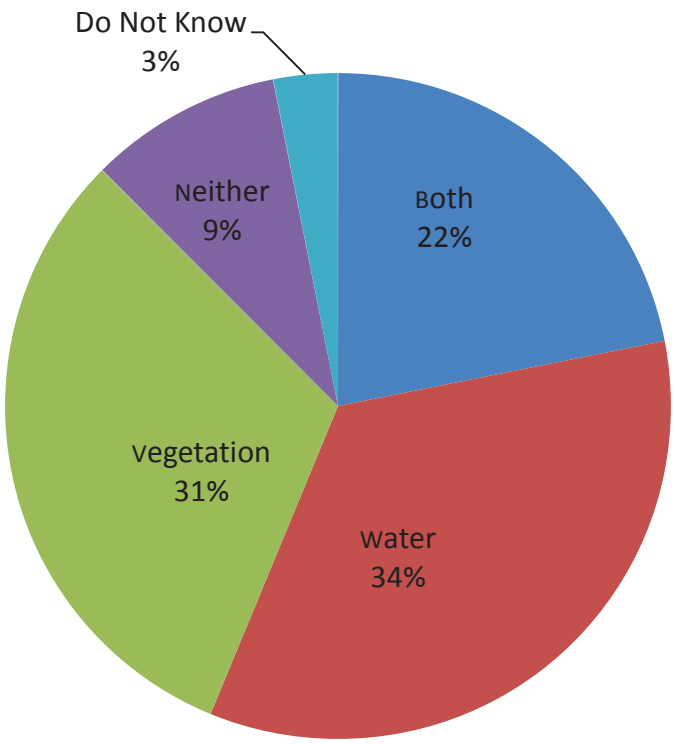

Figure 8. Percentage of respondents reporting that vegetation or water management activities may have contributed to the introduction or spread of invasive *Phragmites* on their property. (N=32)

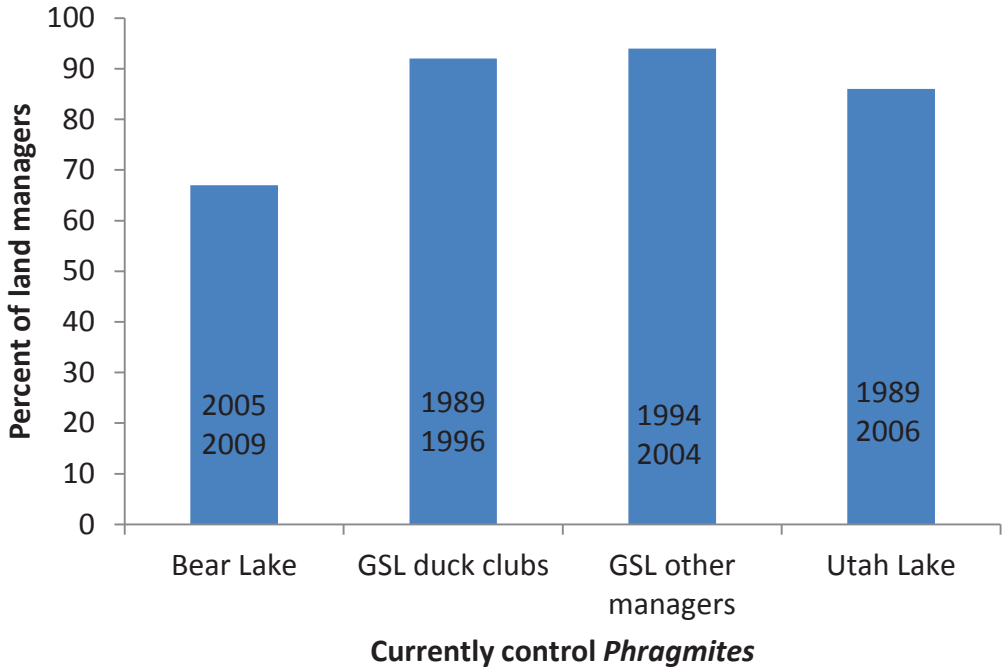

Figure 9. Percentage of land managers by area type that currently control *Phragmites*. Numbers at the base of bars represent the average year that managers detected *Phragmites* (top) and began *Phragmites* control (bottom). Bear Lake N=6, GSL duck clubs N=12, GSL other managers N=17, Utah Lake N=7.

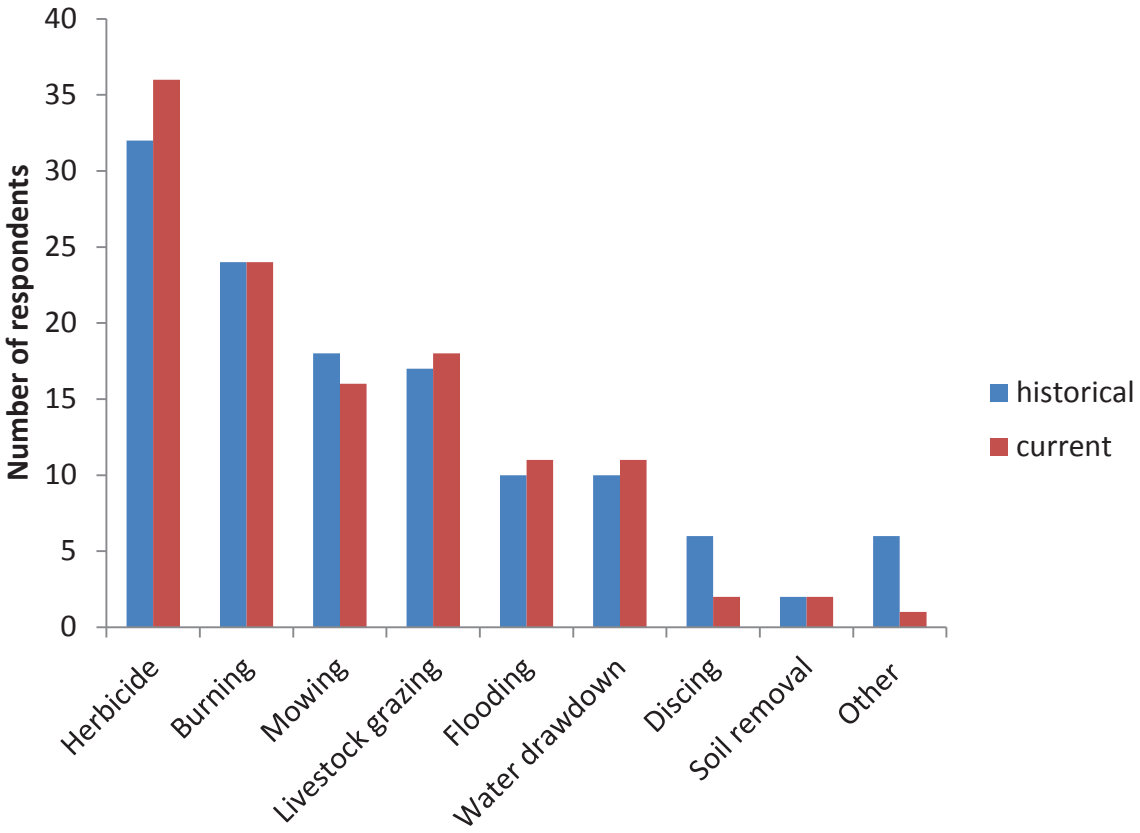

Figure 10. Historical versus current control methods. Other includes “increasing salts in some areas” and ”maintaining high water levels during growing season” (one respondent each; remaining did not specify).

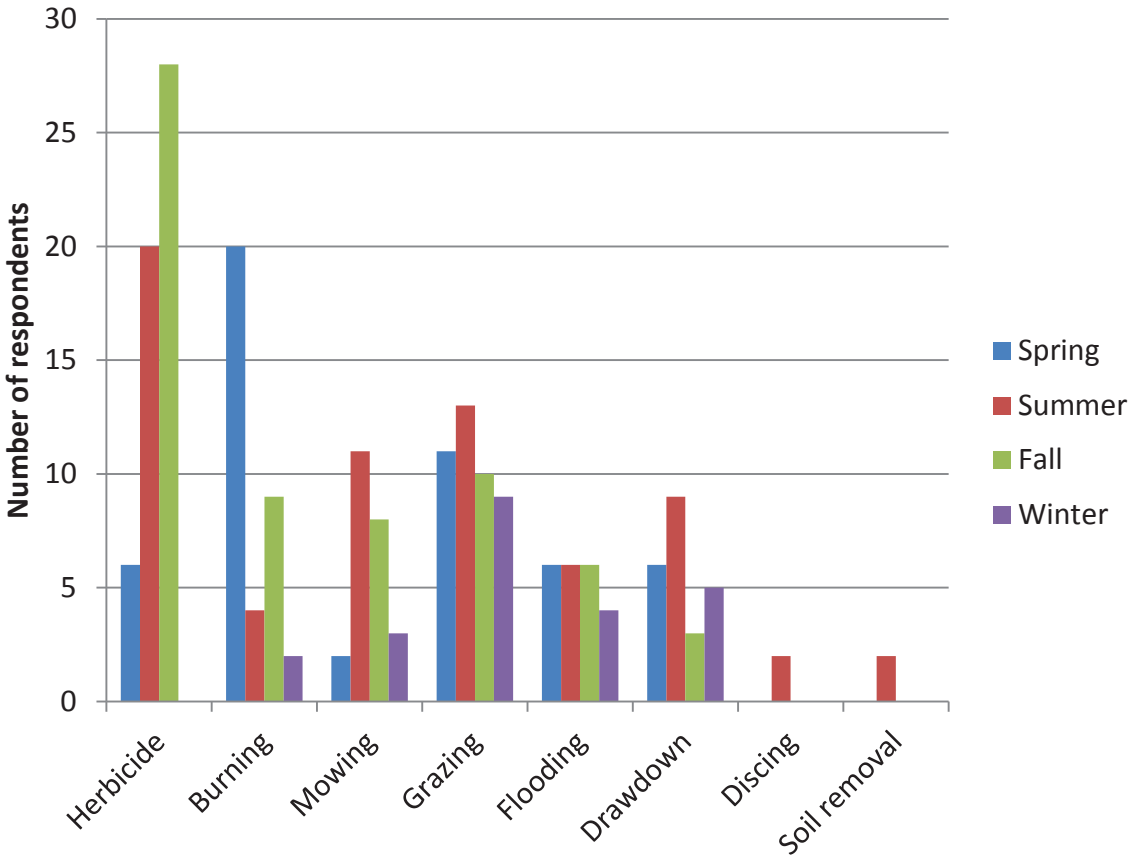

Figure 11. Seasonal timing of control methods. No managers reported livestock grazing at Bear Lake or flooding at Utah Lake.

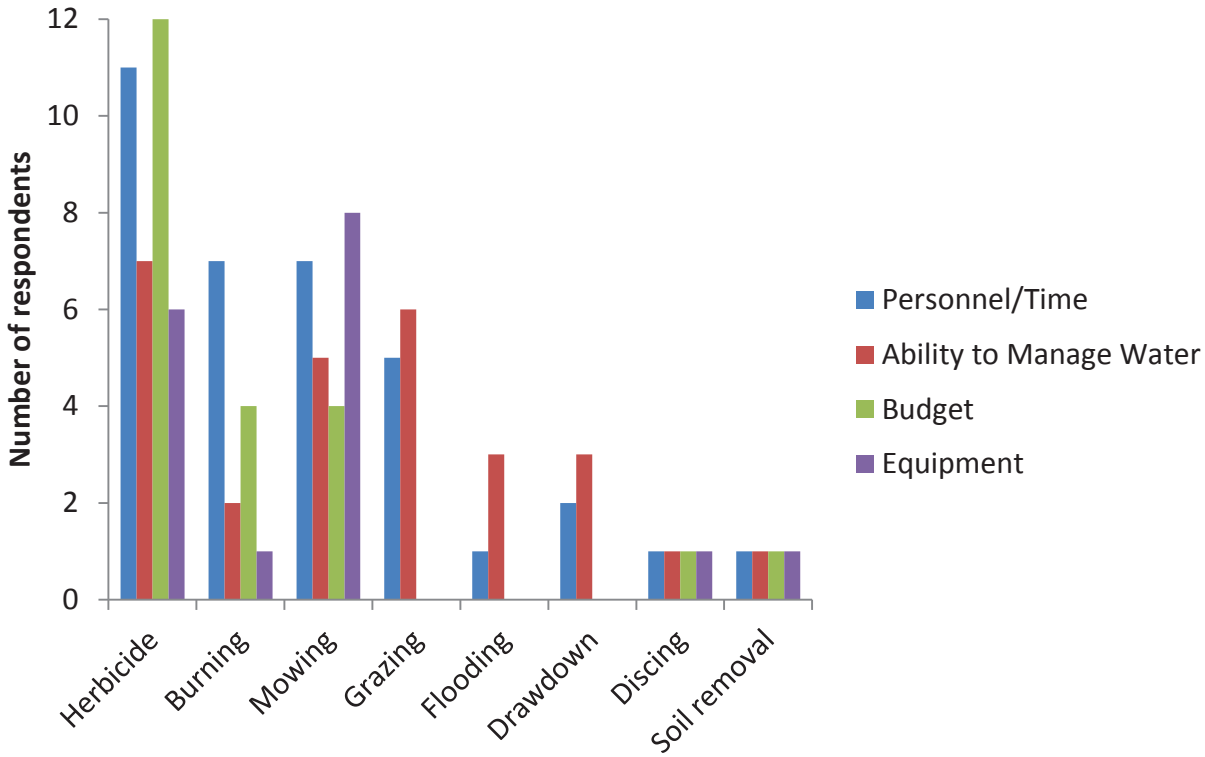

Figure 12. Conflicts of different potential *Phragmites* control methods with other management objectives.

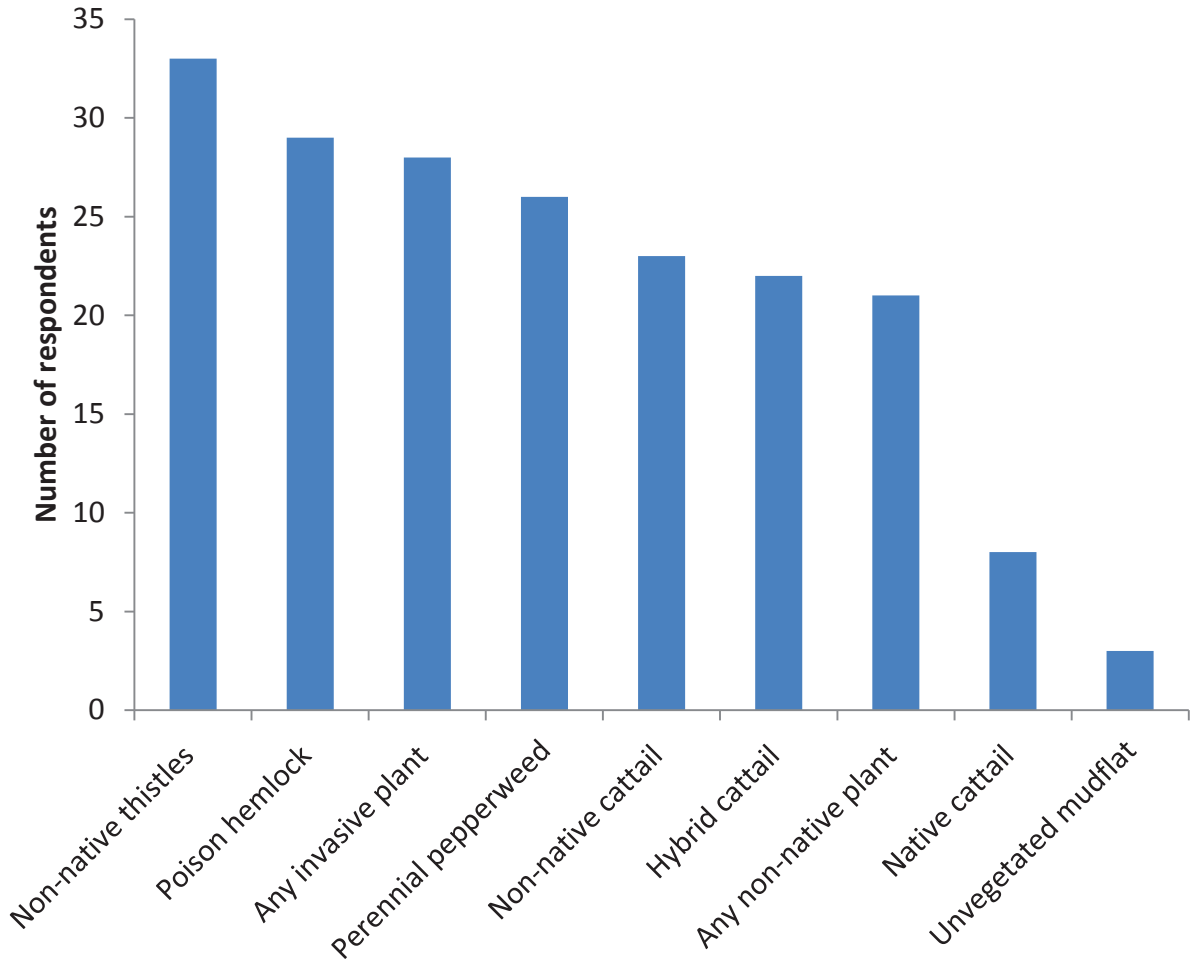

Figure 13. Species, vegetation type, and habitat type land managers aim to *avoid* coming back after invasive *Phragmites* control.

Tables

Table 1. Historic and current management objectives and ranking. Numbers represent percentage of respondents (N=18).

Management objective	A. Historical (>5 years ago)	B. Current (within last 5 years including 2012)	Individually rate your current objectives selected in column B (1=lowest priority, 5=highest priority)				
			1	2	3	4	5
Waterfowl habitat or production	59.5	81.0	9.5	2.4	9.5	4.8	52.4
Non-waterfowl **wetland** habitat	47.6	59.5	2.4	4.8	14.3	19.0	21.4
Non-waterfowl **upland** habitat	45.2	61.9	0.0	9.5	28.6	21.4	14.3
Row crops	16.7	28.6	21.4	7.1	4.8	2.4	2.4
Food plots for wildlife	23.8	35.7	11.9	11.9	9.5	9.5	2.4
Livestock grazing	45.2	54.8	19.0	9.5	7.1	9.5	9.5
Fish production	11.9	21.4	11.9	4.8	4.8	4.8	4.8
Public wildlife viewing / education	23.8	42.9	2.4	9.5	19.0	9.5	11.9
Other, please specify:	28.6	35.7	4.8	2.4	2.4	7.1	19.0

Table 2. Factors affecting top four control methods (other than herbicide). (N=31)

Method	Factors affecting control method	Respondents
Burning	Weather	20
	Air quality permitting	20
	Personnel availability	12
	Ability to manage water	7
	Other: bird nesting (1), size and location of patches (1), hurts dogs paws (1), only use burning following chemical treatment (1)	4
	Other permitting: local fire jurisdiction approval (1), Forestry Fire and State Lands availability (1), did not specify (1)	3
	Budgets	2
Livestock grazing	When water levels were low	8
	The density of the *Phragmites* patch	7
	Weather	6
	The size of the *Phragmites* patch	5
	Other: containing cattle (2), bird nesting (1), livestock availability (1), high water (1)	5
	When we lacked funding for other control methods	4
	Early in the invasion process right after detection	4
	When *Phragmites* invaded historic grazing parcels	4
	Personnel availability	3
	Budgets	0
	In dry years when grazing land was not available elsewhere	0
Mowing	Weather	10
	When water levels were low	10
	Personnel availability	9
	The size of the *Phragmites* patch	7
	The density of the *Phragmites* patch	6
	Budgets	5
	When we lacked funding for other control methods	3
	Other: bird nesting (2), equipment large enough to cut *Phragmite*s (1)	3
	Early in the invasion process right after detection	2
Flooding	Timing of water right	5
	Other: ability to flood deep enough (2), pond configuration cannot flood (1)	4
	Weather	3
	When we had extra water	3
	Personnel availability	1
	When water was being used for other activities	1
	Budgets	0

Table 3. Species, vegetation type, and habitat type land managers would like to see *replace* invasive *Phragmites*.

	Frequency	Percentage
Alkali bulrush *(Schoenoplectus/Scirpus maritimus)*	28	**71.8**
Hardstem bulrush *(Schoenoplectus/Scirpus acutus)*	25	**64.1**
Common threesquare *(Schoenoplectus/Scirpus pungens, americanus, or olneyi)*	22	**56.4**
Native broadleaf cattail *(Typha latifolia)*	15	38.5
Non-native narrowleaf cattail *(Typha angustifolia)*	1	2.6
Hybrid cattail *(Typha x glauca)*	2	5.1
Rushes *(Juncus spp.)*	19	48.7
Spikerushes *(Eleocharis spp.)*	13	33.3
Sedges *(Carex spp.)*	15	38.5
Saltgrass *(Distichlis spicata)*	20	**51.3**
Pickleweed *(Salicornia spp.)*	17	43.6
Iodinebush *(Allenrolfea occidentalis)*	4	10.3
Beggarticks *(Bidens spp.)*	2	5.1
Millet *(Echinochloa spp.)*	8	20.5
Smartweeds *(Polygonum spp.)*	8	20.5
Dock *(Rumex spp.)*	7	17.9
Foxtail barley *(Hordeum jubatum)*	3	7.7
Houndstongue *(Hieracium cynoglossoides)*	1	2.6
Goosefoot *(Chenopodium spp.)*	4	10.3
Willows *(Salix spp.)*	16	41.0
Cottonwoods *(Populus spp.)*	13	33.3
Annual grasses	12	30.8
Any native plant	19	48.7
Any plant – native or nonnative - except *Phragmites*	2	5.1
No vegetation, just open water	12	30.8
No vegetation, just unvegetated mudflat	11	28.2
Other	6	15.4